

US EPA ARCHIVE DOCUMENT

RECENT UPDATES IN WARM

Since the release in 2006 of the 3rd edition of the *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* Report, EPA has restructured the life-cycle emission factor documentation previously published as a single report. As of October, 2010, the resulting documentation is now composed of individual chapters on each material type and waste management practice that EPA has analyzed. This option is more suited to the model structure and allows for easier updating in the future than the previous hard-copy report structure. This Recent Updates document is designed to communicate the structure of updates to WARM and EPA's *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* Report that have occurred since the 3rd edition publication.

With every new version of WARM, the model documentation will be updated to reflect the regular annual updates made to WARM (see section on "Annual Changes" below), as well as other changes and improvements made to the model. Changes listed in "Annual Changes" and "Changes Made in 2014 for WARM Version 13" have not been implemented in other EPA tools including ReCon, iWARM, and SMART BET. Additional details on these changes can be found in the supporting documents on the various material types and waste management options analyzed by EPA.¹ For more information on content and changes to earlier model versions, please see visit the Model History web page.²

ANNUAL CHANGES

Certain updates to underlying WARM data are made annually, and have been implemented in WARM Version 13. These include:

- Assumptions about landfill methane generation are updated based on the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* and EPA's Landfill Methane Outreach Program.
- MSW generation and recovery rates are updated based on the latest *Municipal Solid Waste in the United States, Facts and Figures* report.
- Assumptions about the percent of MSW landfilled and incinerated are updated based on *BioCycle's "State of Garbage in America"* report.
- The composition of yard waste is updated based on the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.
- Various aspects of the U.S. average electricity mix are updated based on EIA's *Annual Energy Review* and the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.
- State electricity grid emission factors are updated based on the eGRID database.
- GHG equivalencies are updated to match EPA's GHG Equivalency Calculator.

CHANGES MADE FOR WARM VERSION 13

In addition to the Annual Changes listed above, other updates made to WARM since Version 12 include updates to various material categories and material management methodologies:

- **Food Waste** – EPA added new emission factors to characterize the energy and GHG emissions associated with the source reduction of food waste.

¹ Available online at <http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html>

² Available online at http://epa.gov/epawaste/conserva/tools/warm/Model_History.html

- These new emission factors include three separate weighted averages of food wastes available in the online version of WARM: Food Waste, Food Waste (meat only), and Food Waste (non-meat). EPA also added individual emission factors for beef, poultry, grains, bread, fruits and vegetables, and dairy products available in the Excel tool.
- The scope of the new emission factors encompasses farm-to-retail and are informed by a variety of food production life-cycle inventories and peer-reviewed studies.
- **Landfilling** – EPA revised the landfill gas methodology in WARM to improve the estimates of gas collection system operating efficiency and align it with more recent scientific literature.
 - This analysis improves upon the landfill gas collection efficiency modeling in WARM and updates the methane oxidation rates.
 - EPA used a Monte Carlo analysis model developed by James Levis and Morton Barlaz to more accurately estimate the fraction of total produced landfill gas that is used beneficially, flared, and vented to the atmosphere at landfills that manage landfill gas.
 - The Excel version of WARM now allows users the option of selecting and reviewing results based on California regulatory gas collection scenario as one of four landfill gas collection scenarios, developed using a Monte Carlo analysis and informed by recent, peer-reviewed scientific literature.
- **Composting** – EPA updated the composting waste management pathway to include fugitive emissions of CH₄ and N₂O during composting.
 - These estimates were derived from a literature review of recent studies on composting.
 - “Green”, or predominantly nitrogenous organic wastes such as yard trimmings have differing fugitive emissions than “brown”, or predominantly carbon waste such as food waste. The Mixed Organics material type uses a weighted average of both types of waste.
- **Source Reduction**—EPA updated the source reduction management pathway to include source reduction emissions for several different mixed material categories, including: Mixed Paper, Mixed Metals, and Mixed Plastics.

CHANGES MADE FOR WARM VERSION 12

Updates made to WARM for Version 12 include the following:

- The Excel macro programming in WARM has been removed. The removal of macros does not affect the results or functionality of the tool. All of the energy and emissions (both MTCO₂E and MTCE) results are displayed automatically (previously, the user could choose which to display).
- The emission factor for the broadloom carpet recycling pathway was updated to include two new plastic resin components. These were based on input and data from Dr. Matthew Realff of the Georgia Institute of Technology, which were informed by the 2009 Carpet America Recovery Effort (CARE) 2009 annual report.
- The energy content of broadloom carpet was updated to incorporate more recent data provided by Dr. Matthew Realff of Georgia Institute of Technology, which were informed by the 2009 Carpet America Recovery Effort (CARE) 2009 annual report.
- Revised the emission factors for three plastics: high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polyethylene terephthalate (PET).

- Developed emission and energy factors for four new plastics to add to the model: Linear low-density polyethylene (LLDPE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC).
- The Mixed Recyclables and Mixed Plastics emission and energy factors were updated to remove the inclusion of LDPE as a recycled plastic type. Previously, these factor incorporated LDPE, but updated data for recycling LDPE plastic were unavailable.
- The Mixed Recyclables and Mixed Plastics emission and energy factors were updated to reflect revisions to the underlying numbers in the virgin and recycled HDPE and PET emission factors.
- The emission and energy factors for aluminum cans were updated based on life-cycle data from the Aluminum Association. In addition, new emission and energy factors for aluminum ingot were developed.
- The emission and energy factors for polylactide (PLA), a biopolymer, were developed using life-cycle data provided by NatureWorks.

CHANGES MADE BETWEEN THE 3RD EDITION OF THE REPORT AND WARM VERSION 11

The primary changes and improvements to the life-cycle analysis since the 3rd edition of the report include the following:

- **Overarching Changes**
 - New GHG equivalencies were added to show the change in emissions calculated by the user in terms of gallons of gasoline, cylinders of propane, railway cars of coal, as a percentage of the annual CO₂ emissions from the U.S. transportation sector, and as a percentage of the annual CO₂ emissions from the U.S. electricity sector. All the GHG equivalencies were updated to match EPA's GHG Equivalency Calculator.³
 - EPA modified the interface to display results in metric tons of carbon dioxide equivalent (MTCO₂E) as the default unit for GHG emissions, but results are still available in units of metric tons of carbon equivalent (MTCE).
 - The 1605(b) functionality in the Excel version of WARM was removed because 1605(b) no longer supports the reporting of savings from waste reduction.
- **Changes affecting Material Types**
 - New emission factors were added for six construction and demolition (C&D) materials: asphalt concrete, asphalt shingles, drywall, fiberglass insulation, vinyl flooring, and wood flooring.
 - Emission factors for tires were updated: the tire recycling pathway now encompasses ground and shredded rubber applications and no longer includes retreading as a recycling application. This change has decreased the overall net benefit of recycling scrap tires.
 - The material type “corrugated cardboard” was renamed to “corrugated containers” to eliminate redundancy of the former naming convention.
- **Changes affecting Waste Management Options**

³ Available online at <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>

- The Excel version of WARM now incorporates region-specific electricity grid factors to more accurately model emissions associated with avoided generation of electricity due to landfill gas recovery in the landfilling pathway and waste-to-energy in the combustion pathway. This change increases the flexibility of WARM and allows the user to generate more precise results for their scenario. This functionality is not available in the online version of WARM where the default national average electricity grid mix (i.e., national average) is implicit.
- The Excel version of WARM includes an updated method for estimating the landfill gas collection efficiency, allowing the user to select between three landfill gas collection efficiency scenarios based on specific landfill recovery characteristics: typical operation, worst-case collection, and aggressive gas collection. This change increases the flexibility of WARM and allows the user to generate more precise results for their scenario. This functionality is not available in the online version of WARM where the default national average landfill gas collection scenario (i.e., typical operation) is implicit.
- Component-specific decay rates were added to the Excel version of WARM for all organic materials to more accurately model the rate at which each material decays within a landfill under given landfill moisture conditions: dry, average, wet, or bioreactor. This change increases the flexibility of WARM and allows the user to generate more precise results for their scenario. This functionality is not available in the online version of WARM where the default national average landfill moisture conditions (i.e., average) scenario is implicit.
- The waste-to-energy combustion pathway energy values (MMBTU) incorporate a revised methodology that considers the ratio of mass burn combustion facilities (17.8%) and the national average electric utility grid combustion efficiency (32%).
- The recycling emission factors for the Mixed Paper material types were modified to include updated recycled boxboard data.

FUTURE UPDATES TO WARM

WARM is regularly updated to expand its coverage of materials and waste management pathways, to keep its methodology consistent with current research and literature, and to maintain the accuracy of its background data. Updates to WARM that may be implemented in the near future include the following:

- **Anaerobic Digestion:** EPA is currently reviewing scientific literature and models to assess the GHG emissions from anaerobic digestion for a variety of organic materials in WARM. This effort will lead to the addition of anaerobic digestion as an alternative waste management pathway in a future update to the model.
- **Donations:** EPA is currently assessing the viability of adding donations as an alternative pathway for waste management, building off of the source reduction pathway and the reuse alternative described in the memo “Modeling Reuse in EPA’s Waste Reduction Model” available through the WARM Documentation page.
- **Electronics:** In order to improve the accuracy of WARM’s estimates of GHG emissions associated with the material management of electronic devices, EPA is evaluating the impact of new electronics production methods and components on the existing emission factors for personal computers.